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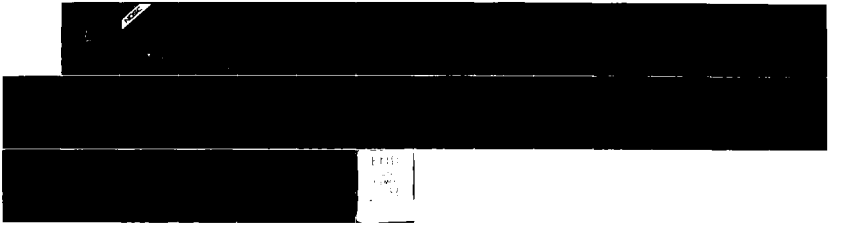

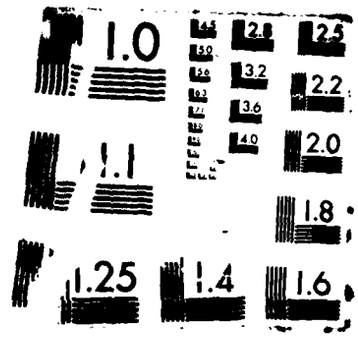
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Perspective Display Study

S. V. Bemis
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This experiment compared accuracy and response time of subjects on a conventional tactical display with their accuracy and response time on a perspective tactical display. The distinguishing feature of the perspective display is its representation of vertical, as well as horizontal information in perspective. Altitude information is symbolically presented on the display. In contrast, current tactical display systems provide only two-dimensional views requiring numerical representation for altitude information. The subjects were volunteers from surrounding Naval facilities. The subjects were required to perform two tasks: (1) detect threats, and (2) select the closest interceptor for each detected threat. Errors and response time were recorded for each subject by a computer program. The experiment revealed a significant reduction in errors of detection and interception with the use of a perspective display. Response time for selecting interceptors was greatly reduced.

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INTRODUCTION

With the advent of more sophisticated computer hardware and increased computer display resolution, new options are available for communicating information to tactical display operators. More specifically, in the present study, a perspective display was investigated for Navy tactical display systems. In contrast to conventional tactical displays, this perspective display depicts vertical as well as horizontal information for aircraft, surface vessels, and submarines. The perspective display would not be a replacement, but rather a supplement to current tactical displays.

The purpose of this research was to compare operator performance on a conventional tactical display with performance on the perspective display and determine the significance of vertical information where relative altitude differences between threats and interceptors may be important. In conventional tactical displays the operator "hooks" the symbol to obtain altitude information from data readouts. With a perspective display relative altitude information is quickly visible while more accurate information may still be obtained from data readouts.

BACKGROUND

Conventional Navy displays present information to the operator on relative position, orientation, and movement of aircraft, ships, and other platforms. On the basis of this information the operator makes recommendations and takes actions involving the deployment of friendly assets. The use of a perspective display may enhance such operations by reducing the information processing load for the operator and decreasing operator reaction times. Uttal, Azzato, and Brogan (1982) indicate that another advantage of perspective displays may be higher margins of safety in critical control situations. Merritt (1982) suggests that previous research has not evaluated perspective displays in many applications due to the belief that perspective information may be irrelevant to a particular task.

Recently, a study done by Smith, Ellis, and Lee (1982) used data tags on a conventional display to provide altitude information to pilots in a simulated perceived threat and avoidance scenario. This study found that the majority of maneuvers made by pilots were in a horizontal avoidance rather than vertical fashion. They cited reasons for this as (1) the greater horizontal latitude allowed pilots under Federal Communications Commission (FCC) ruling compared to vertical spacing, (2) concerns for passenger comfort, and (3) fuel conservation. However, Ellis, and McGreevy (1983) suspected that this tendency to maneuver in a horizontal fashion could be a result of the type of display and encounter used. Specifically, the preference for horizontal avoidance maneuvers could be unique to a conventional display with only two dimensions portrayed. Accordingly, avoidance maneuvers could be modified by implementation of a perspective display for oncoming traffic. Pilots would then be able to maneuver more frequently in a vertical fashion.

Ellis and McGreevy (1983) compared pilots' avoidance maneuvers when using a perspective cockpit traffic display with their avoidance maneuvers on a conventional plan-view display. Previous investigations showed that pilots tended to maneuver horizontally rather than vertically to avoid intruding aircraft. These avoidance maneuvers included turns towards the intruding aircraft or away from the intruding aircraft while the altitude remained approximately the same. Aircraft on the conventional and perspective displays were represented by schematic airplane-like symbols. Vertical lines on the perspective display extended from the symbol to a grid where horizontal separation was represented. Tic marks on the vertical lines in the

perspective display divided present or future positions of aircraft into intervals of 1000 feet. The number of vertical maneuvers pilots made with the perspective display increased twofold over the vertical maneuvers made with the conventional display. The relative differences between the two displays suggest that use of the perspective display results in avoidance maneuvers that achieve greater separation between aircraft.

SCOPE

This experiment was designated to test performance accuracy of subjects who must detect a threat and elect the closest interceptor. Subjects were required to perform both tasks (detect a threat and select the closest interceptor for each threat) in order to compare performance in two display conditions. The two display conditions were (1) the conventional display and (2) the perspective display. See Figures 1 and 2. The fundamental difference between the two displays was the manner in which altitude information was presented to the operator. Both conventional and perspective displays had three modes of operation which were accessed by keys on the keyboard. The three modes were (1) pick, to gain altitude status only, (2) detect, to target a threat as well as obtain altitude information, and (3) intercept, to select a friendly interceptor, which also gave altitude information.

In the conventional display condition, subjects were required to press a key on the keyboard to enter the detect mode, followed by "hooking" the symbol to obtain altitude information. In the perspective display condition, vertical separation was more readily presented on the screen. However, the subject still had the option of hooking the symbol to obtain an exact numerical representation of the altitude. This numerical value was presented in the top right corner of the display. In addition to type of display, another factor was tested. Symbols were shape-coded in all conditions but redundantly color-coded in only half of these conditions. Color was included to determine its effectiveness in perspective displays.

VARIABLES AND HYPOTHESES

The between-subjects independent variable was color. The within-subjects independent variable was display condition (conventional and perspective). The dependent measures were (1) latent time to detect possible threats, (2) response time for selection of interceptors, (3) number of incorrect selections (false alarms), and (4) number of omissions for both threats and interceptors.

Based on previous research (Uttal, et al., 1982; Merritt, 1982; Ellis and McGreevy, 1983), it was hypothesized that subjects would select the correct interceptor for detected threats more accurately and quickly with the perspective display than with the conventional tactical display. It was expected that no significant differences would be found in search and detection between the conventional display and the perspective display. The null hypothesis regarding color was that there would be no difference in accuracy or response time on the two tasks between color and the black and white condition.

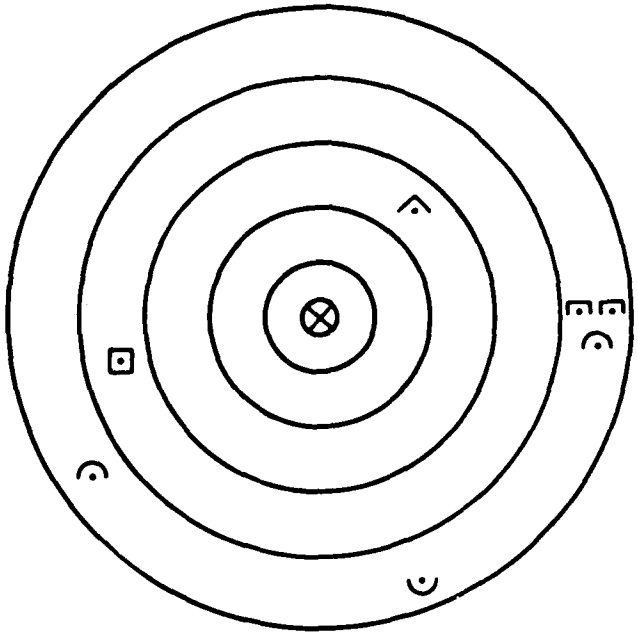


Figure 1. Conventional display.

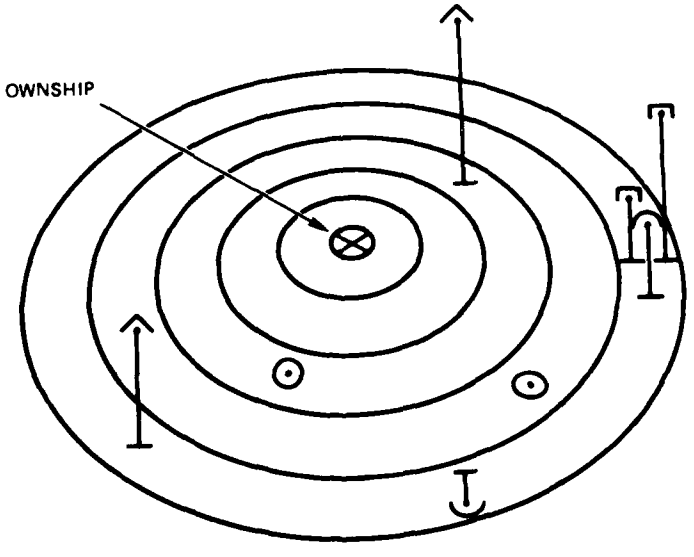


Figure 2. Perspective display.

METHOD

SUBJECTS

The subjects were 47 staff operational personnel from surrounding Naval facilities who qualified for this experiment by passing a visual acuity test with a corrected vision of 20/20. Subjects had a mean of 9.4 years of Naval experience. Because of a data-collection problem with the computer software in the color conventional display condition, data for only 39 of the 47 subjects were collected.

EQUIPMENT

The Genisco, Model #6210, high-resolution graphic display terminal with a Microvax II as a host via Direct Memory Access (DMA) was used for both the conventional and perspective display conditions. The display was 14 inches wide by 11 inches high with a resolution of 1392 x 1024 pixels. Symbol width on the conventional 2-D display was 0.19 inch and symbol height was 0.12 inch. Symbol size varied on the perspective display from 0.178 inch wide and 0.11 inch high for distant symbols to 0.21 inch wide and 0.13 inch high for the closest symbols. The display represented a circular area with a 24-mile radius. Ownship was positioned in the center of the area.

A digitizer pad and pen were used to "hook" symbols on the display. Subjects used three keys on the Genisco keyboard to select the desired mode (pick, detect, or intercept). In addition to written instructions, the experimental task was demonstrated with an 8-mm color video cassette recorder on a 19-inch Sony color monitor. A standard visual acuity chart (Form 2C) was used to test vision.

SCENARIO

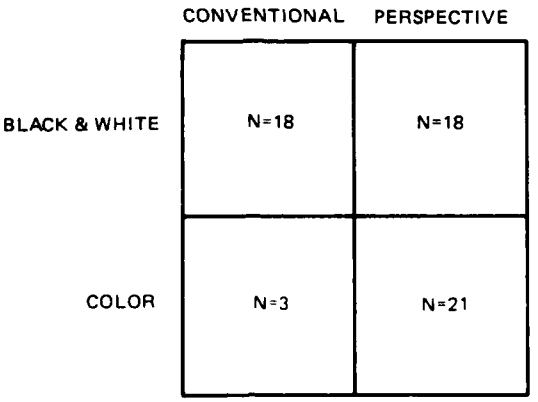
The north Arabian Sea was the location for the 30-minute scenario. Each 30-minute scenario presented 15 threats. A threat was defined as any hostile aircraft that appeared on the display or any unknown aircraft that left an air corridor. No more than 30 symbols were presented on the display at any time.

In this north Arabian Sea setting, major air traffic flew east and west in the flight corridors. The tactical symbology represented ownship (aircraft carrier), 15 friendly aircraft (flying at 360 knots), 12 commercial aircraft (400 knots), 3 friendly surface vessels (5-33 knots), 6 Iranian P-3s (200 knots), and 2 Soviet Mays (400 knots). Fifteen of the 20 commercial aircraft were inside the flight corridors. Only 30 symbols were presented on the display at any one time. When a craft left the 24-mile area portrayed on the display, another craft appeared. Fifteen threats were interspersed throughout the 30-minute scenario. The series of threats included 4 commercial aircraft flying east and west outside the corridor, 4 commercial aircraft leaving the corridor at varying points, 1 Soviet May flying out of Adan, 1 Soviet May diving out of the corridor, 2 Iranian P-3s traveling from Iran to Adan, 1 Iranian P-3 traveling from Adan to Iran, 1 Iranian P-3 flying over ownship that suddenly dives toward ownship, and 1 unknown submarine heading north.

EXPERIMENTAL DESIGN

The experimental design was a 2 x 2 mixed factorial design as shown in Figure 3. Each subject was tested in both the conventional and perspective display conditions. The perspective display was fixed at a 41-degree viewing angle for this experiment. The conventional display showed the traditional Plan Position Indicator (PPI) overhead view

with ownship centered on the display. Symbols were shape-coded in the two display conditions while color-coding was used redundantly for only half of the subjects. Shape-coding denoted the category of the symbol (surface, subsurface, or air) and the identity of the craft (friendly, hostile, or unknown). Color was coded on one dimension only; that is, color redundantly denoted the identity of the craft. Red represented hostile craft, yellow denoted unknown craft, and green represented friendly craft.



NOTE:
All within-subjects analyses included only subjects with data in both experimental conditions. N=# of subjects in each display condition.

Figure 3. Experimental design.

The same two scenarios were used for all subjects in both display conditions. The scenarios differed in only one respect. Each scenario had a different sequence of threats to which the subjects were instructed to respond. A threat was defined as the appearance of a hostile craft anywhere on the display or any unknown craft that left an air corridor. The scenarios, along with color and display condition, were counterbalanced to offset any learning effect that otherwise might have occurred. See Table 1.

Table 1. Order of presentation used to counterbalance display conditions and scenarios.

Subj	1st Display Condition	Scenario Used	2nd Display Condition	Scenario Used	Color/Black & White
1	Conventional	1	Perspective	2	Black & White
2	Conventional	1	Perspective	2	Color
3	Perspective	1	Conventional	2	Black & White
4	Perspective	1	Conventional	2	Color
5	Conventional	2	Perspective	1	Black & White
6	Conventional	2	Perspective	1	Color
7	Perspective	2	Conventional	1	Black & White
8	Perspective	2	Conventional	1	Color

* Subject number 9 received the same instructions as subject number 1 and the series was repeated throughout the experiment.

More simply, the first subject was tested with Scenario 1 in the conventional display condition. The subject was then run through Scenario 2 in the perspective display condition. Color was added to the second subject. That is, color was alternated between

subjects. Display condition was then reversed so that subjects were run in the perspective display condition first, then the conventional condition with Scenarios 1 and 2 respectively. Scenarios were then reversed for the next four subjects so that Scenario 2 was viewed first. This strategy was used throughout the experiment.

Prior to initiating the experiment, subjects were given written instructions (Appendix A or B), a short narrated video, and a practice session on a training scenario. With these three sources of information, subjects were taught to perform two central tasks and understand the three modes of operation: pick, detect, and intercept. The first task required subjects to search the display and detect any threats. Each of the 15 threats appeared on the display one at a time. The second task consisted of choosing the closest interceptor. The closest interceptor referred to the friendly aircraft that was nearest the detected threat both horizontally and vertically. A numerical readout of altitude information for any craft on the display was obtained by depressing the pick mode key and "hooking" the respective symbol. Obviously, in the conventional display condition it was important that numerical altitude information be obtained to accurately select the closest interceptor. This option was available in both display conditions.

PROCEDURE

Subjects were tested in a partitioned area in a computer laboratory. Normal staff operations continued in the laboratory surrounding the testing area. However, the testing area was covered with an opaque tarpaulin so that illumination resembled the darkened room in the Combat Information Center (CIC). Consequently, noise and illumination replicated normal CIC operating conditions.

Each subject was first administered the visual acuity test. After confirming 20/20 (corrected) vision, the subject was given written instructions about the task. Separate instructions were made for the color and black and white conditions (Appendices A and B). The instructions described the three modes of operation: pick, detect, and intercept. The pick mode was used to gain only a numerical value for the altitude of any hooked symbol on the display. The altitude was then presented in the top right corner of the display. The detect mode was used to target a threat for interception. The third mode, intercept, was used to select an appropriate interceptor. In all three of these modes peripheral equipment was used. The subjects were instructed on the use of the peripheral digitizer pad and pen. The digitizer pad and pen controlled a crosshair (cursor) on the screen. It was with the crosshair that the desired craft was pinpointed for altitude information, targeting, or interception, depending on which mode the subject was operating. Subjects were instructed to work as quickly and accurately as possible.

After reading the instructions, the subject watched an 8-minute video to become acquainted with the equipment. Then the subject was presented with a practice scenario. The practice scenario consisted of four threats, lasting a total of 5 minutes. If the practice scenario was successfully completed, the subject was tested on the first 30-minute scenario. A 5-minute break was given to each subject after the first scenario and before commencing the second scenario. After completion of the second scenario, the subjects were given a questionnaire asking relevant information (Appendix C). The questionnare obtained information about preference of display condition, age, years in service, and pertinent experience. The subjects were then debriefed and thanked for their participation.

DATA COLLECTION

The computer recorded latency to detection for each threat and response time for each interception per subject. Mean latency and mean response time for each subject were computed. Errors, including omissions, false detections, and false interceptions, were recorded for all events. Questionnaires were coded for bivariate regression analysis.

RESULTS

Weighted and unweighted analyses of variance (ANOVA) were performed to determine any significant differences between the perspective display and the conventional display for the number of errors made and reaction time. All within-subjects analyses for the perspective and conventional display conditions included subjects with data in both experimental conditions. The ANOVAs showed that significantly fewer errors were made using the perspective display. See Figure 4 for the mean errors for each task.

MEAN ERRORS

CONDITION	DETECT	INTERCEPT
CONVENTIONAL DISPLAY	2.78 *(0.08)	8.0 *(1.76)
PERSPECTIVE DISPLAY	1.83 *(0.08)	4.83 *(1.34)

MEAN RESPONSE TIME IN SECONDS

CONDITION	DETECT	INTERCEPT
CONVENTIONAL DISPLAY	45.65 *(9.67)	84.10 *(8.79)
PERSPECTIVE DISPLAY	41.06 *(9.26)	54.93 *(9.59)

*STANDARD DEVIATION

Figure 4. Mean errors and response times of all subjects.

An analysis of total errors for the task of detecting threats showed that significantly fewer errors were made in the perspective display conditions ($F = 5.84$, $p > 0.05$) for both false detections and omissions. False detections refer to symbols that were incorrectly selected as a threat. Omissions are threats that were not detected. A separate ANOVA showed that the preponderance of errors were due to false detections rather than omissions. The largest advantage found for the perspective display was the substantial reduction of errors for the task of selecting interceptors ($F = 66.32$, $p > 0.01$). This finding was consistent for both false interceptions and omissions. False interceptions refer to symbols that were incorrectly selected as the closest interceptor. If the subject failed to select an interceptor an error of omission was made.

It was hypothesized that response time would be less in the perspective display condition for interceptor selection due to the vertical spacing of symbols. The results of the analysis showed that response time was meaningfully shorter for the perspective display ($F = 58.94$, $p > 0.01$) for interceptor selection. See Figure 4. However, no significant differences in response time were found between the two display conditions for threat detection. For the between-subjects variable of color versus black and white, the findings are inconclusive due to a data-collection error in the computer software.

Regression analyses were performed to determine any correlation between (1) response time and errors for the combined tasks of detecting threats and selecting interceptors for both display conditions, and (2) response time and errors for each task (detect only and intercept only) for both display conditions. No significance was found. In addition, regression analyses were performed on length of Naval experience (measured in years of Naval service) and age with errors and reaction time. These analyses showed that only length of Naval experience correlated with errors and reaction time. As Naval experience increased, response time both to detect and to intercept increased on the conventional and perspective displays ($r = 0.267$, $t(19) = 1.21$, $p > 0.05$, $y = 2.158 + 0.6456 (X)$. However, it was also found that as Naval experience increased, fewer errors were made in detection and interception for both display conditions. [$r = -0.351$, $t(19) = -1.635$, $p > 0.05$, $y = 16.49 - 0.399 (X)$].

To discover any bias against the perspective display, a separate bivariate regression analysis was performed correlating years of Naval experience with the time to intercept on the perspective display only. Here a stronger relationship was found. Subjects with more Naval experience took longer to select an interceptor than those with less experience [$r = 0.393$, $t(19) = 1.713$, $p > 0.05$, $y = 22.032 + 0.4918 (X)$].

DISCUSSION

The results of this experiment clearly show the utility of the perspective display in reducing errors of all types and in decreasing reaction time to send interceptors. It was expected that subjects would have slower response times for selecting interceptors in the conventional display because subjects needed to use the "pick" key to determine the precise altitude of possible interceptors. Many subjects commented that the graphically depicted vertical separation in the perspective display condition was an excellent feature which could expedite interceptor selection for Operation Specialists in the Fleet.

The perspective display significantly reduced errors in interceptor selections. This finding was expected due to the graphic representation of the interceptor's altitude in relation to the hostile or unknown craft. However, the perspective display significantly reduced detection errors as well, which was not expected, because the perspective display has tic marks attached to each air symbol. Initially, the possibility that these additional tic marks may even cause a sensory overload in subjects was considered. This

possibility was disproved, since subjects' detection errors were reduced significantly in the perspective display condition when compared to the conventional display condition. Most subjects made many errors in both detecting and intercepting while using the conventional display, which could be very costly in real-life situations. The perspective display reduced all types of errors, and could help Navy Tactical Data System (NTDS) operators to do their job better.

The results of the comparison between color versus black and white are not conclusive because of the unfortunate loss of data. The amount of data which was obtained for the color condition indicated that color may reduce errors of all types and may also produce faster reaction times for both the perspective and conventional display conditions. Further research is necessary to determine the usefulness of color-coding on the perspective display. Most of the subjects stated that color-coded symbols aided in threat detection. Hostile symbols were red in the color condition.

The results of the regression analysis showed that men with more Naval experience were taking longer to complete tasks in both display conditions, while the analysis showed that chronological age was not a factor. Naval experience was not a confounding variable since subjects were tested in both display conditions. Although response time for selecting interceptors was greatly reduced for all subjects in the perspective display condition, subjects with more Naval experience tended to take longer to send interceptors in the perspective display condition than less experienced subjects. Since Naval Operations Specialists use the conventional display consistently, subjects with more experience may have needed more time to adapt to a new display type. However, since they made fewer errors, this could be the result of these more experienced subjects being more careful in their choice of the best interceptor to send.

A survey given to each subject at the conclusion of the test period showed that 44 subjects preferred the perspective display, while only 3 preferred the conventional one (the data from the pilot study were also included in these results). Subjects' comments were included on the survey sheet. One typical comment was, "It is a great small area item. The immediate recognition of a best available resource could be quite valuable." Many commented that the display was "outstanding" or "very good," as well as many comments praising the immediate "availability of altitude information," which could lead to "faster interceptions of unknown and hostile craft." Three subjects preferred the conventional display because they were familiar with it.

This display was developed as an adjunct for the present NTDS display. Although the perspective display can be rotated for different fields of view, it was fixed at a 41-degree angle for this study. One of the advantages of this particular display is the rotating capability that allows operators to view symbols from all angles. The zooming capability was not activated for this study.

Display density and complexity were not studied in this experiment. Future research is necessary to determine the effects of overlapping symbols and data tags in order to effectively evaluate the usefulness of the perspective display for the Combat Information Center (CIC). A summary of the factors that still need to be investigated before this display can be implemented are (1) usefulness of color-coding in this particular display, (2) display density and complexity, and (3) the effect of the rotated field of view on operator performance.

The use of a perspective display for other applications was also investigated. LCDR Hass (1984) suggested that one possible application for the perspective display might be the Mine Warfare Planning System. Some ships still use charts and colored

pieces of paper for mapping minefields. Mine areas are viewed as a cylinder when in reality they are usually a series of spheres or a single hemisphere centered on the bottom. Future research could investigate the use of perspective displays as an alternate to the present mapping methods. Another area that was mentioned by a number of subjects would be the use of this display for air traffic control, as well as the air intercept controller in the CIC.

SUMMARY AND CONCLUSIONS

This experiment revealed a significant reduction in errors of detection and interception with the use of the perspective display. Response time for selecting interceptors was greatly reduced, as expected, in the perspective display condition. No difference existed in response time for threat detection between the two display conditions. The regression analyses showed that no correlation existed between (1) response time and errors for the combined tasks of detecting threats and selecting interceptors for both display conditions (perspective and conventional), and (2) response time and errors for each task (detect only and intercept only) for both display conditions. Regression analyses were further performed on length of Naval experience and age with errors and reaction time. These analyses showed that only length of Naval experience correlated with errors and reaction time. As Naval experience increased response time both to detect and to intercept increased and error rate decreased on the conventional and perspective display conditions.

The results of this experiment show the potential of the perspective display to reduce errors and response time in Air Interceptor Controller (AIC) displays in the CIC. Before this type of display can be implemented in the Fleet, it is essential that display density and complexity be studied on the perspective display.

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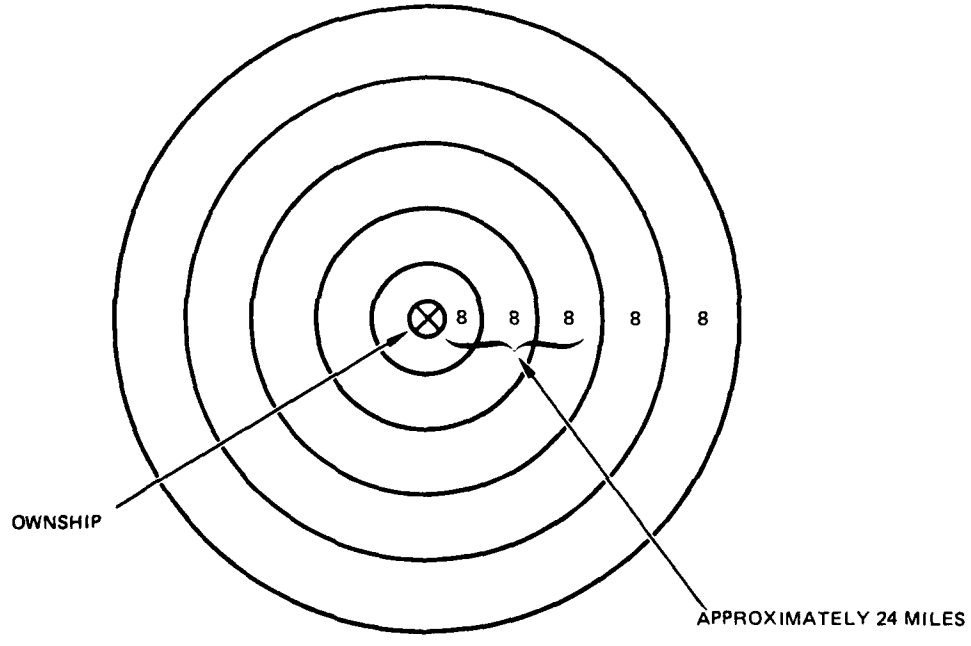
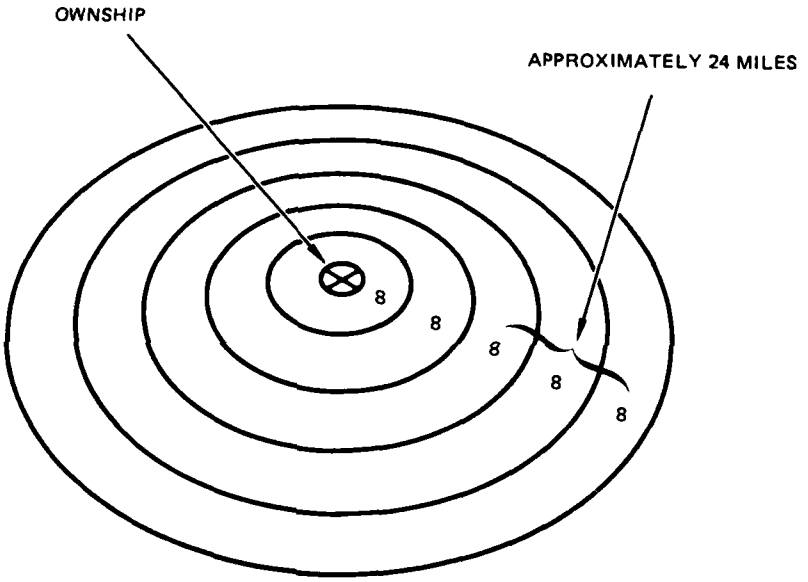
APPENDIX A - INSTRUCTIONS FOR COLOR-CODED DISPLAYS

Instructions

This is an experiment to see how well different types of tactical displays work. You will view displays similar to tactical displays. For half of the time during this experiment, you will be using a normal 2-D display. The other half of the time you will be using a 3-D perspective display, which will give you not only horizontal information on craft location, but vertical information as well. Your ship (ownship) is the circle with the cross in it at the center of the display. Around ownship is approximately 40 miles of sea and airspace. Each circle represents approximately 8 miles distance from the ship. The following are samples of the displays used.

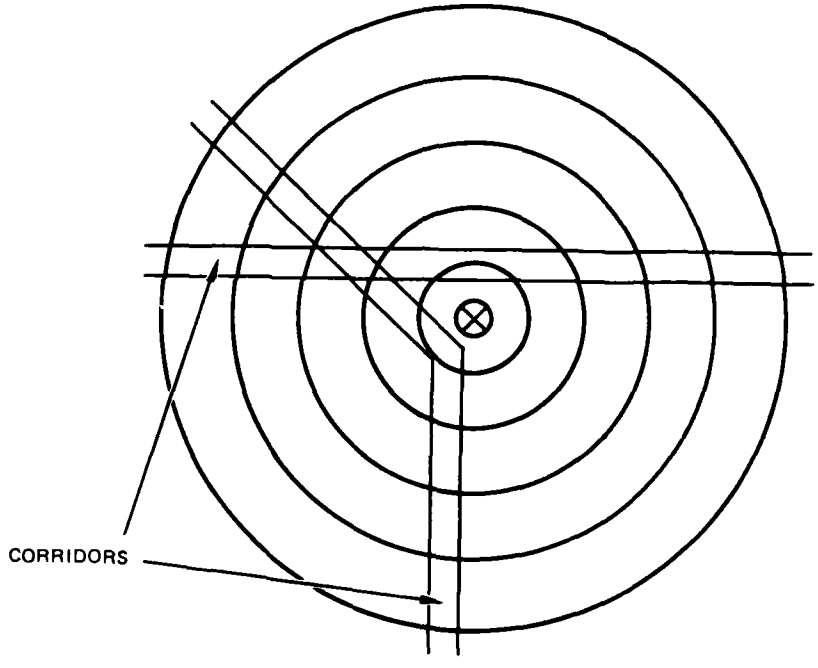


2-D

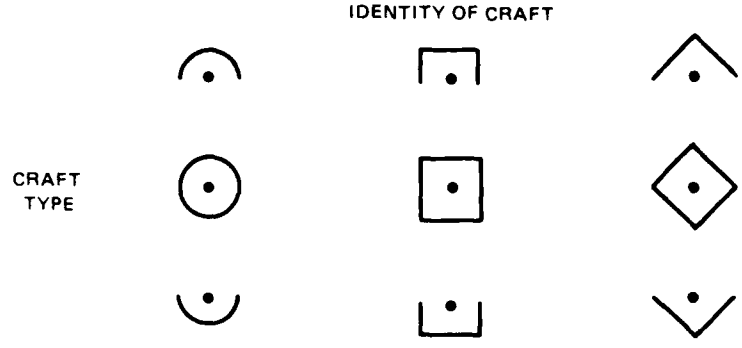


3-D

There will also be two air corridors on the display. The two air corridors are shown by the two sets of parallel lines. The following is a sample of the air corridors.



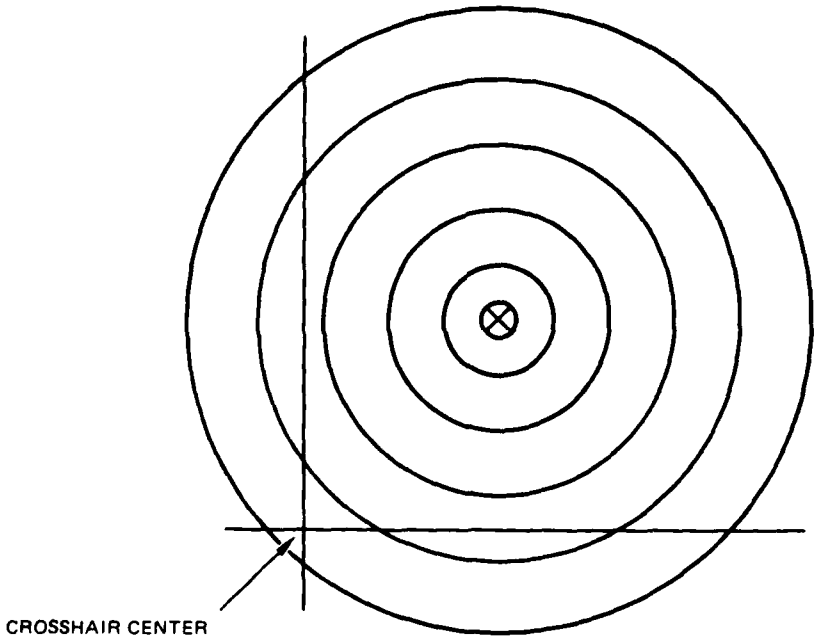
In this experiment you will be required to detect threats and select interceptors. A threat is when any unknown symbol appears outside of the air corridors or leaves an air corridor, and when a hostile ship appears in or out of the air corridors (anywhere on the display). Only one threat at a time will occur. The interceptor used must be a FRIENDLY AIRCRAFT. The following are the symbols used.



The basic NTDS symbols are used in this experiment.

In addition to these symbol shapes denoting the type and identity of the craft, color is also used redundantly to denote the identity of the craft. RED is used to represent hostile craft, YELLOW is used to represent unknown craft, and GREEN is used to represent friendly craft.

NOTE: A CROSSHAIR, IN EITHER BLUE OR YELLOW, WILL BE USED AS THE CURSOR TO HOOK THE SYMBOLS. WHEN HOOKING A SYMBOL, THE CROSSHAIR CENTER MUST BE DIRECTLY OVER THE SYMBOL YOU WISH TO HOOK. IF THE CROSSHAIR RETURNS IMMEDIATELY, THE CROSSHAIR WAS NOT PROPERLY PLACED. PLEASE TRY TO HOOK THE SYMBOL AGAIN. AN EXAMPLE OF THE CROSSHAIR IS SHOWN BELOW.



During the experiment, you will sit in front of your display. The keyboard is directly in front of you. You will use three keys on the keyboard (F1, F2, and P). A digitizer tablet is on the righthand side of your keyboard. You will use the digitizer pan on the digitizer pad to move the cursor to the particular symbol. The following is the proper procedure to operate this tactical display.

Procedure

When a threat is seen, follow this procedure:

1. Press the F2 key on the keyboard in front of you. The word "detect" will appear in place of the word "zoom" in the top right center of the display.
2. Wait for crosshair to appear on the screen.
3. Move digitizer pen on digitizer pad until the center of the crosshair is directly on the hostile or unknown threat.
4. Press digitizer pen down on digitizer pad.
5. Number tag will appear next to the threat.
6. If crosshair reappears immediately, information was not received. You will need to repeat steps 4 & 5.

Now you are ready to select the closest friendly interceptor. THE INTERCEPTOR MUST BE A FRIENDLY AIRCRAFT. Follow this procedure:

1. Locate the closest friendly interceptor (remember aircraft only) on display.
2. Now press the F1 key on the keyboard in front of you. The word "intrcpt" will appear in place of the word "zoom" in the top right center of the display.
3. Wait for crosshair to appear.
4. Move digitizer pen on digitizer pad until the center of crosshair is directly on the craft you wish to use to intercept the threat.
5. Press digitizer pen down on digitizer pad.
6. Number tag will appear next to this craft.
7. If crosshair returns immediately, then information was not received. You will need to repeat steps 4 & 5.

NOTE: DO NOT WORRY IF YOU DO NOT ACTUALLY SEE THE THREAT INTERCEPTED ON THE SCREEN. THE THREAT IS OVER ONCE BOTH THE THREAT AND INTERCEPTOR CRAFT HAVE A TAG NEXT TO THEM. THE THREAT WILL SOON DISAPPEAR FROM THE SCREEN.

If you want precise altitude information on any craft displayed, then follow this procedure:

1. Press the P key on the keyboard in front of you. The word "pick" will appear in place of the word "zoom" on the top right center of the display.
2. Wait for the crosshair to appear.
3. Move digitizer pen on digitizer pad until the center of crosshair is directly on which craft you desire information.
4. Press digitizer pen down on digitizer pad.
5. Look to top righthand side for information.
6. If crosshair reappears immediately, then information was not received. You will need to repeat steps 3 & 4.

NOTE: ANY CRAFT THAT HAS BEEN PICKED AS A THREAT OR AN INTERCEPTOR WILL HAVE ITS PRECISE ALTITUDE INFORMATION DISPLAYED IN THE TOP RIGHT-HAND CORNER OF THE DISPLAY (THE SAME PLACE AS THE P KEY ALTITUDE INFORMATION).

For easier hooking, wait for craft to be clear of corridor and grid lines.

If you press one of the keys in error, push down on the digitizer pen approximately 5 times with the crosshair center not touching any symbols (on a blank space). Be sure to wait for the crosshair to reappear each time before pushing down again.
Please try to work as QUICKLY and as ACCURATELY as possible.

Remember any unknown craft appearing as a threat (outside of air corridors) must be detected and must be intercepted. You will only need to do this once for each threat.

Once a craft has been detected and intercepted, you will not need to continue detecting this craft. Wait for the next threat to occur.

Detect only gives altitude and range information.

Unknown aircraft in the air corridors DO NOT need to be detected unless they leave air corridor.

Note: The "tic marks" and cross at the bottom on the 3-D display are NOT speed leaders. It just gives the relative altitude of craft.

When you see "Well Done" on the screen, you will know that you have finished that part of the experiment. Please inform the experimenter that you are done.

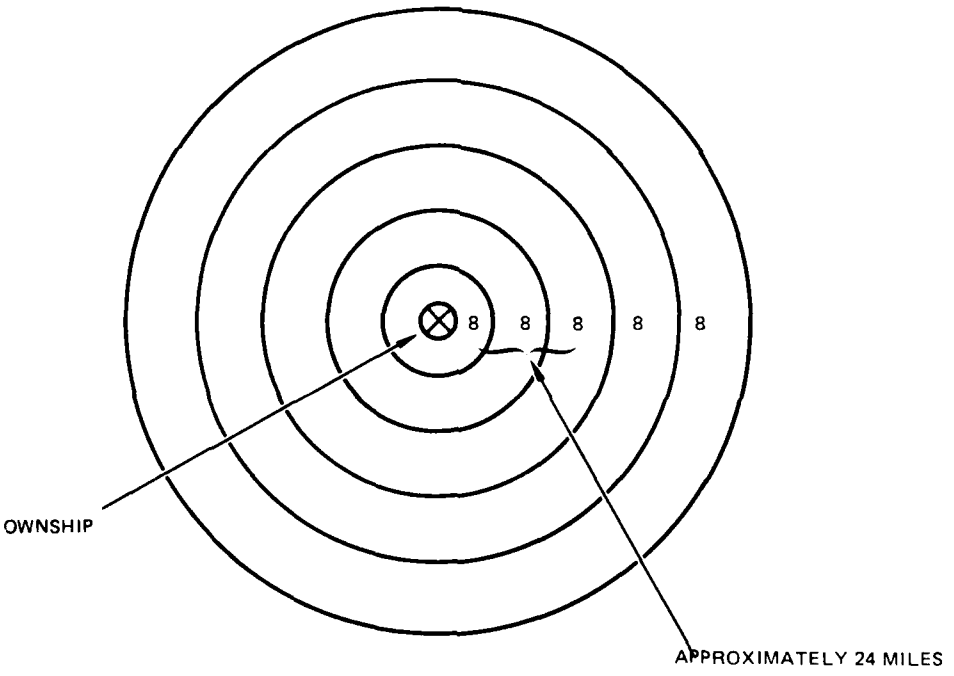
Do you have any questions?

Are you ready to begin a practice session?

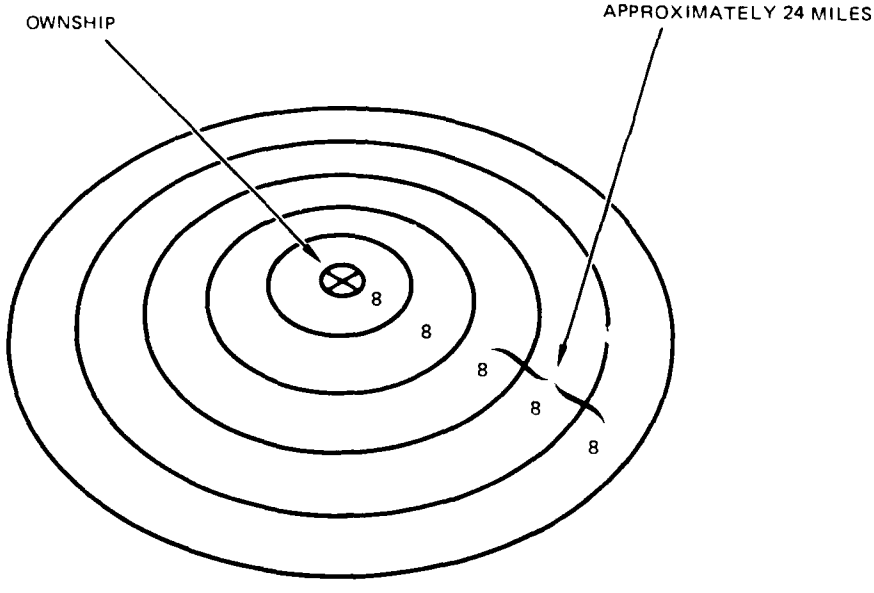
APPENDIX B - INSTRUCTIONS FOR BLACK AND WHITE DISPLAYS

Instructions

This is an experiment to see how well different types of tactical displays work. You will view displays similar to tactical displays. For half of the time during this experiment, you will be using a normal 2-D display. The other half of the time you will be using a 3-D perspective display, which will give you not only horizontal information on craft location, but vertical information as well. Your ship (ownship) is the circle with the cross in it at the center of the display. Around ownship is approximately 40 miles of sea and airspace. Each circle represents approximately 8 miles distance from the ship. The following are samples of the displays used.

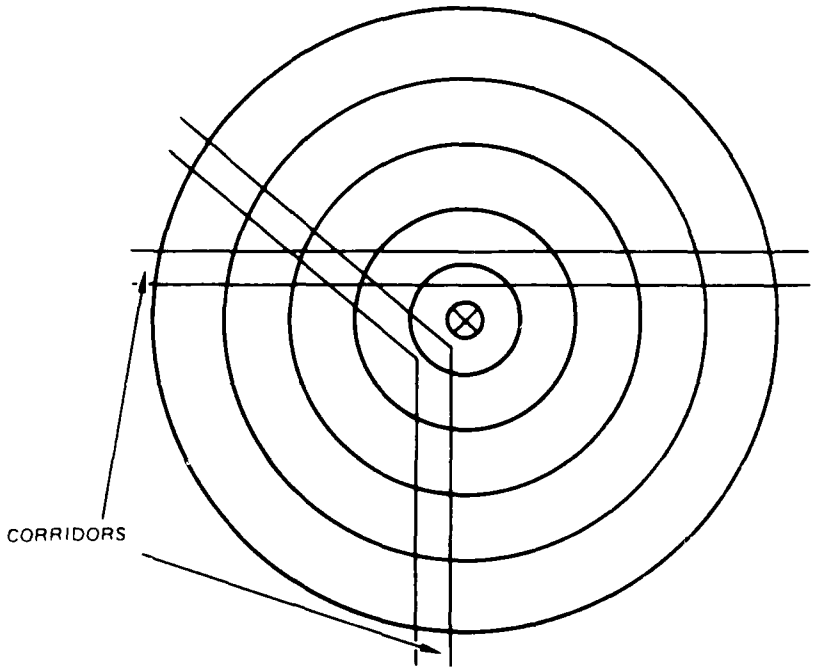


2-D

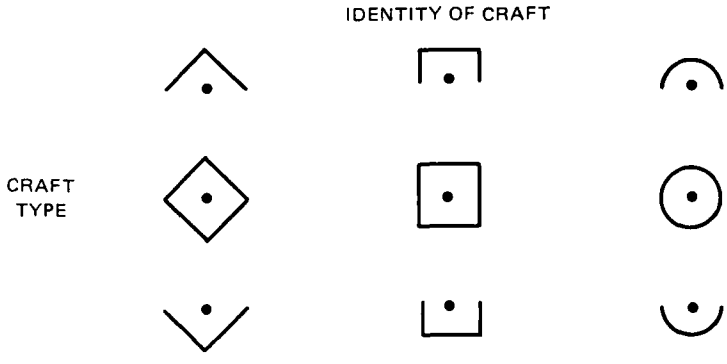


3-D

There will also be two air corridors on the display. The two air corridors are shown by the two sets of parallel lines. The following is a sample of the air corridors.

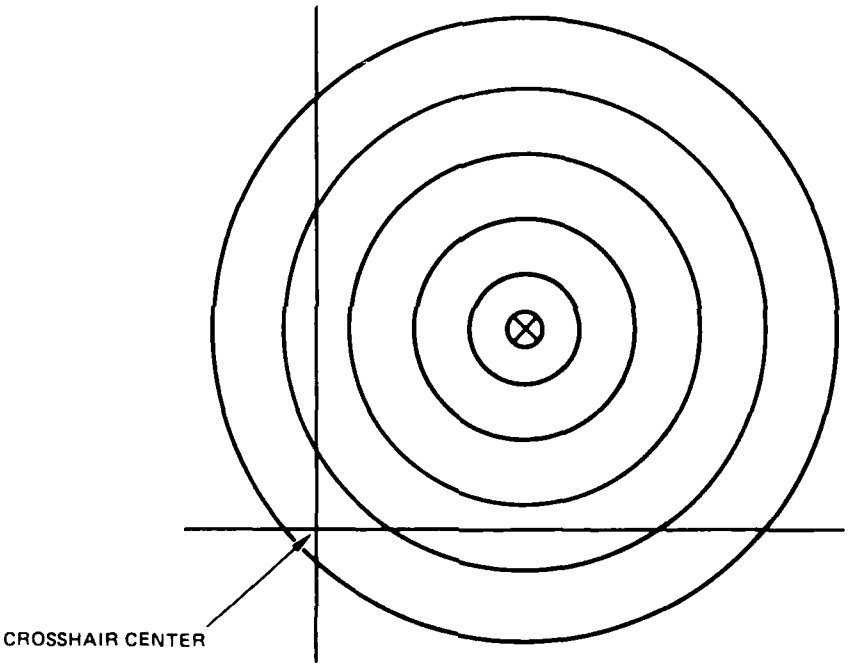


In this experiment you will be required to detect threats and select interceptors. A threat is when any unknown symbol appears outside of the air corridors or leaves an air corridor, and when a hostile ship appears in or out of the air corridors (anywhere on the display). Only one threat at a time will occur. The interceptor used must be a FRIENDLY AIRCRAFT. The following are the symbols used.



The basic NTDS symbols are used in this experiment.

NOTE: A CROSSHAIR WILL BE USED AS THE CURSOR TO HOOK THE SYMBOLS. WHEN HOOKING A SYMBOL, THE CROSSHAIR CENTER MUST BE DIRECTLY OVER THE SYMBOL YOU WISH TO HOOK. IF THE CROSSHAIR RETURNS IMMEDIATELY, THE CROSSHAIR WAS NOT PROPERLY PLACED. PLEASE TRY TO HOOK THE SYMBOL AGAIN. AN EXAMPLE OF THE CROSSHAIR IS SHOWN BELOW.



During the experiment, you will sit in front of your display. The keyboard is directly in front of you. You will use three keys on the keyboard (F1, F2, and P). A digitizer tablet is on the righthand side of your keyboard. You will use the digitizer pen on the digitizer pad to move the cursor to the particular symbol. The following is the proper procedure to operate this tactical display.

Procedure

When a threat is seen, follow this procedure:

1. Press the F2 key on the keyboard in front of you. The word "detect" will appear in place of the word "zoom" in the top right center of the display.
2. Wait for crosshair to appear on the screen.
3. Move digitizer pen on digitizer pad until the center of the crosshair is directly on the hostile or unknown threat.
4. Press digitizer pen down on digitizer pad.
5. Number tag will appear next to the threat.
6. If crosshair reappears immediately, information was not received. You will need to repeat steps 4 & 5.

Now you are ready to select the closest friendly interceptor. THE INTERCEPTOR MUST BE A FRIENDLY AIRCRAFT. Follow this procedure:

1. Locate the closest friendly interceptor (remember aircraft only) on display.
2. Now press the F1 key on the keyboard in front of you. The word "intrcpt" will appear in place of the word "zoom" in the top right center of the display.
3. Wait for crosshair to appear.
4. Move digitizer pen on digitizer pad until the center of crosshair is directly on the craft you wish to use to intercept the threat.
5. Press digitizer pen down on digitizer pad.
6. Number tag will appear next to this craft.
7. If crosshair returns immediately, then information was not received. You will need to repeat steps 4 & 5.

NOTE: DO NOT WORRY IF YOU DO NOT ACTUALLY SEE THE THREAT INTERCEPTED ON THE SCREEN. THE THREAT IS OVER ONCE BOTH THE THREAT AND INTERCEPTOR CRAFT HAVE A TAG NEXT TO THEM. THE THREAT WILL SOON DISAPPEAR FROM THE SCREEN.

If you want precise altitude information on any craft displayed, then follow this procedure:

1. Press the P key on the keyboard in front of you. The word "pick" will appear in place of the word "zoom" on the top right center of the display.
2. Wait for the crosshair to appear.
3. Move digitizer pen on digitizer pad until the center of crosshair is directly on which craft you desire information.
4. Press digitizer pen down on digitizer pad.
5. Look to top righthand side for information.
6. If crosshair reappears immediately, then information was not received. You will need to repeat steps 3 & 4.

NOTE: ANY CRAFT THAT HAS BEEN PICKED AS A THREAT OR AN INTERCEPTOR WILL HAVE ITS PRECISE ALTITUDE INFORMATION DISPLAYED IN THE TOP RIGHT-HAND CORNER OF THE DISPLAY (THE SAME PLACE AS THE P KEY ALTITUDE INFORMATION).

For easier hooking, wait for craft to be clear of corridor and grid lines.

If you press one of the keys in error, push down on the digitizer pen approximately 5 times with the crosshair center not touching any symbols (on a blank space). Be sure to wait for the crosshair to reappear each time before pushing down again.
Please try to work as QUICKLY and as ACCURATELY as possible.

Remember any unknown craft appearing as a threat (outside of air corridors) must be detected and must be intercepted. You will only need to do this once for each threat.

Once a craft has been detected and intercepted, you will not need to continue detecting this craft. Wait for the next threat to occur.

Detect only gives altitude and range information.

Unknown aircraft in the air corridors DO NOT need to be detected unless they leave air corridor.

Note: The "tic marks" and cross at the bottom on the 3-D display are NOT speed leaders. It just gives the relative altitude of craft.

When you see "Well Done" on the screen, you will know that you have finished that part of the experiment. Please inform the experimenter that you are done.

Do you have any questions?

Are you ready to begin a practice session?

APPENDIX C - EXPERIMENT QUESTIONNAIRE

Name and Rate _____

Male ( ) Female ( )

Date of Birth _____/_____/_____

Years in Navy _____

OS "A" School ( ) Yes
( ) No

Additional OS training:

_____

_____

OS Shipboard experience:

_____

_____

Which display did you find easier to use?

( ) 3-D perspective
( ) 2-D perspective

Please list any additional comments that you have about the experiment that you have just participated in. We are especially interested in what you think about this 3-D perspective display.

_____

_____

_____

_____

_____

Thank you very much for participating in this experiment. Have a nice day.

APPENDIX D - GLOSSARY

1. Air Corridor - Lines that cut through both displays to signify the legal area for commercial and unknown aircraft to pass through. (Commercial flight patterns.)

2. CIC - Acronym for Combat Information Center.

3. Crosshair - Replaced a cursor for both conventional and perspective display conditions, serving the same function as a cursor by facilitating the picking, detecting, and intercepting of craft. Graphically, it consisted of a vertical and a horizontal line across the screen. The intersection of these two lines was used to target the object of interest for this computer simulation. (See instructions.)

4. Detect Mode - Used to detect and target a threat.

5. Errors of Omission - Threats that were not detected or when a subject failed to select an interceptor.

6. False Detections - Symbols that were incorrectly selected as an interceptor.

7. False Interceptions - Symbols that were incorrectly selected as an interceptor.

8. Hooking - The process of targeting a craft to perform a computer operation, (i.e., pick, detect, or intercept). This was done by placing the center of the crosshair over the desired symbol (using digitzer pad and pen) and then pressing down on the digitizer pen.

9. Intercept Mode - Used to select an appropriate interceptor for a detected threat.

10. Pick Mode - Used to obtain altitude information on any hooked symbol.

11. PPI - Acronym for Plan Position Indicator. This is the tactical display in CIC.

12. Threat - A threat was defined as the appearance of a hostile craft anywhere on the display or any unknown craft that left an air corridor.